

***Ingerana borealis* (Annandale, 1912): a new record from Mizoram (India), with notes on its systematic position and natural history**

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A study on the distribution of *Ingerana borealis* was carried out in Mizoram. Based on morphological comparison with type species of the genera *Ingerana*, *Occidozyga* and *Phrynoglossus* and data on behaviour, *Micrixalus borealis* is allocated to the genus *Ingerana* Dubois, 1987. The study also reveals its occurrence up to 1000 m asl, previously unrecorded for this species. The species lives in lotic habitat and is well adapted not only to the slow-moving waters, but also to the fast flowing permanent streams in and near forests. The holophoront of *Micrixalus borealis* is redescribed and recently collected specimens from Mizoram allocated to this species are described.

INTRODUCTION

ANNANDALE (1912) described *Micrixalus borealis* from the collections of the Abor Expedition based on 11 specimens. It was only DUBOIS (1987) who reconsidered generic allocation of this species using the character states given in original description. He allocated the species to *Phrynoglossus* Peters, 1867 as it shares with this genus the absence of vomerine teeth, the enlarged, rounded finger and toe tips without grooves and the indistinct tympanum. Morphological data and recent phylogenetic studies showed that *Phrynoglossus* and *Occidozyga* Kuhl & Van Hasselt, 1822 are members of a monophyletic clade (MARMAYOU et al., 2000;



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KOSUCH et al., 2001) transcribed by FEI et al. (1990) and DUBOIS (2005) as the subfamily *OCCIDOZYGINAE* Fei, Ye & Huang, 1990, and by others (INGER, 1993; FROST et al., 2006) by synonymisation of *Phrynoglossus* with *Occidozyga*. Thus, *Micrixalus borealis* was listed as *Occidozyga borealis* by FROST et al. (2006). The *OCCIDOZYGINAE* might include further ranoid groups as molecular data (BOSSUYT et al., 2006) indicate close relationship of *Occidozyga lima* (Gravenhorst, 1829), *O. laevis* (Günther, 1859) and *Ingerana tenasserimensis* (Sclater, 1892).

In the last decade, more specimens of *Micrixalus borealis* from a large range including Bangladesh, Bhutan, NE India and Myanmar have been collected and observed in the wild and the onomatophore deposited in the collection of Zoological Survey of India, Kolkata, has been studied. At present, *M. borealis* is known from several north-eastern states of India, including Arunachal Pradesh, Meghalaya (MATTHEW & SEN, 2003) and Nagaland (AO et al., 2003). Outside India, it has also been recorded from Bhutan (DUBOIS, pers. comm.) and from the Rangamati Hill district in Bangladesh and the Arkan state in Myanmar (FROST et al., 2006). We report here its occurrence in the Mizoram state of north-eastern India.

Recent observation of new specimens and behavioral data from the field made generic allocation to either *Phrynoglossus* or *Occidozyga* somehow doubtful. Therefore *Micrixalus borealis* is compared to specimens of the genera *Occidozyga*, *Phrynoglossus* and *Ingerana* as defined by their onomatophores and a new generic allocation is proposed. We provide a description of these newly collected specimens, along with diagnostic characters for the species, its distribution and ecological notes. For the sake of completeness, a redescription of the onomatophore of *Micrixalus borealis* is given.

MATERIAL AND METHODS

Museum abbreviations. – BMNH, Natural History Museum, London, United Kingdom; MNHN, Muséum National d'Histoire Naturelle, Paris, France; ZMB, Zoologisches Museum Berlin, Berlin, Germany; ZSI, Zoological Survey of India, Kolkata, India.

Specimens studied. – MIZORAM. Aizawl district: MZU-ZOO A.108, A.115, A.118, 3 ♀, Mizoram University Campus (23°43.081'N, 92°43.668'E; 915 m asl); MZU-ZOO A.36, A.38, 1 ♂, 1 ♀, Tamdil National Wetland (23°44.399'N, 92° 57.313'E; 745 m asl); MZU-ZOO A.43, A.46, 1 ♂, 1 ♀, Durlui (23°53.508'N, 92°29.056'E; 110 m asl). Kolasib district: MZU-ZOO A.31, A.33-34, 1 ♂, 2 ♀, Tuitun stream (23°58.213'-58.402'N, 92°41.055'-41.104'E; 300-325 m asl); MZU-ZOO A.122, 1 ♂, Zanlawntlang Reserved Forest (23°56.116'N, 92°43.465'E; 748 m asl).

Our specimens were collected and preserved in 8 % formalin. Ecological and morphometric data were collected for all specimens. Voucher specimens were catalogued in the Museum of Zoology department, Mizoram University (MZU-ZOO). Selected morphometric measurements were made to the nearest 0.01 mm with dial calipers (Mitutoyo series No. 505-671). Morphometric and meristic characters largely followed those of SENGUPTA (2008). Onomatophore description follows the standards of OHLER & DUBOIS (2006) and BORDOLOI et al. (2007).

Other specimens used for comparisons. – *Ingerana borealis* (Annandale, 1912): ZSI 16932, holophoront, sex not investigated, Rotung (1300 ft = 400 m asl; 28°07'N, 95°12'E), South of

Yembung, Arunachal Pradesh, India; MNHN 1994.6489-6492, 4 ♂, Deothang (1000 m asl; 226°53'N, 91°30'E), Samdrup Jongkhar District, Bhutan. *Ingerana tenasserimensis* (Sclater, 1892): ZSI 10429, symphoront, sex not investigated, Tenasserim expedition (near 12°04'N, 99°01'E), Myanmar; MNHN 1989.0718-0719, Banthat Mts. (7°30'N, 99°40'E), Thailand. *Occidozyga lima* (Gravenhorst, 1829): MNHN 1999.6112-6132, Luang Prabang (19°53'N, 102°08'E), Laos. *Phrynoglossus martensii* Peters, 1867: ZMB 5645, holophoront, young ♀ Bangkok (13°34'N, 100°13'E), Thailand; MNHN 1997.5359-5369, 9 ♂, 2 ♀, Ben En National Park (19°35'N, 105°28'E), Thanh Hoa Province, Vietnam.

Measurements. – SVL, snout-vent length; SL, snout length; EN, distance from eye to nostril; NS, distance from nostril to snout; TE, distance from tympanum to eye; IN, internarial distance; IOD, interorbital distance; IUE, distance between upper eyelids; UEW, upper eyelid width; ED, eye diameter; HTYD, horizontal tympanic diameter; HL, head length; HW, head width; HDN, head depth at nostril; MN, distance from back of mandible to nostril; MFE, distance from back of mandible to front of eye; MBE, distance from back of mandible to back of eye; IFE, distance between front of eyes; IBE, distance between back of eyes; FLL, forelimb length; HAL, hand length; F₁, length of first finger; F₂, length of second finger; F₃, length of third finger; F₄, length of fourth finger; HLL, hindlimb length; TL, shank length; TW, shank width; FL, thigh length; T₁, length of first toe; T₂, length of second toe; T₃, length of third toe; T₄, length of fourth toe; T₅, length of fifth toe; IMT, length of inner metatarsal tubercle; F₁D, width of first finger disc; F₃D, width of third finger disc; T₁D, width of first toe disc; T₄D, width of fourth toe disc; MTFD, distance from distal edge of metatarsal tubercle to maximum incurvation of web between third and fourth toe; TFTF, distance from maximum incurvation of web between third and fourth toe to tip of fourth toe; MTFF, distance from distal edge of metatarsal tubercle to maximum incurvation of web between fourth and fifth toe; FFTF, distance from maximum incurvation of web between fourth and fifth toe to tip of fourth toe.

GENERIC ALLOCATION

Comparison of morphological characters (tab. 1) of specimens allocated to *Micrixalus borealis* and specimens of *Ingerana*, *Occidozyga* and *Phrynoglossus* present quite a complex pattern of variation. In fact some character states, as the absence of vomerine teeth, apply to all species observed and might be variable within genera, as *Ingerana tasanae* (Smith, 1921), a larger species allocated to the genus *Ingerana*, has vomerine teeth (TAYLOR, 1962). *Occidozyga lima* can be distinguished by a series of character states that should be autapomorphies in cladistic analysis, such as the presence of an outer metatarsal tubercle and of a tarsal tubercle, the pointed tongue shape, the pointed tit-like subarticular tubercles, the complete webbing, the pearly tipped tubercles on dorsal and ventral skin and the colour pattern on posterior shank which shows continuous dark and light transverse stripes (DUBOIS & OHLER, 2001). These character states cannot be observed in either *Ingerana tenasserimensis*, *Phrynoglossus martensii* or *Micrixalus borealis*. *Phrynoglossus martensii* can be distinguished from *Ingerana* by the length of first finger (longer than second), the absence of grooves on discs, the presence of a metatarsal web, and the skin bearing glandular warts. It shares with *Occidozyga lima* the presence of metatarsal web.

Table 1. – Comparison of 22 characters, including data on behaviour, observed on specimens of the type species of the genera *Ingerana*, *Occidozyga* and *Phrynoglossus* with the holophoront (holotype) of *Micrixalus borealis*.

Genus	<i>Occidozyga</i>	<i>Phrynoglossus</i>	<i>Ingerana</i>	<i>Micrixalus borealis</i>
Type species or holophoront	<i>Rana lima</i> Gravenhorst, 1829	<i>Phrynoglossus martensii</i> Peters, 1867	<i>Rana tenasserimensis</i> Schlater, 1892	ZSI 16932
Vomerine teeth	Absent	Absent	Absent	Absent
Tongue	Pointed	Rounded	Notched	Notched
Tympanum	Indistinct	Indistinct	Distinct	Indistinct
Tympanic fold	Poorly distinct	Distinct	Distinct	Distinct
Length of finger I	Equal to II	Longer than II	Much shorter than II	Much shorter than II
Tips of fingers	Pointed	Rounded	Dilated	Dilated
Grooves on digital discs	Absent	Absent	Present	Absent
Subarticular tubercles	Prominent, pointed	Rounded	Rather large, flat, indistinct	Large, distinct
Outer metatarsal tubercle	Present	Absent	Absent	Absent
Tarsal tubercle	Present	Absent	Absent	Absent
Webbing	Complete	Large	Small	Moderate
Metatarsal web	Present	Present	Absent	Absent
Tarsal fold	Long, distinct	Short, distinct	Short, indistinct	Short distinct
Dorsal skin	Pearly tipped tubercles or spines	Scattered tubercles	Fine net-like skin ridges	Fine net-like skin ridges
Ventral skin	Pearly tipped tubercles or spines	Smooth	Smooth	Smooth
Lateral line system	Present	Absent	Absent	Absent
Coloration	Greyish brown with darker pattern forming two more or less distinct mid-dorsal lines	Greyish brown with mid-dorsal darker band outlined by lighter lines	Usually light dorsolateral stripes; brown with darker spots and scattered white blotches	Greyish brown, darker pattern including band between eyes and chevron; lighter dorsolateral lines
Posterior shank	Continuous dark and light transverse stripes	Whitish with a fine peppering of darkish pigment	Brown, slightly lighter mottled	Brownish mottling
Vocal sacs	Internal vocal sac	Internal vocal sacs	Not known	Internal vocal sacs
Nuptial spines	Present	Present	Not known	Present
Colour of egg	Brown and white	Whitish	Whitish	Whitish
Amplexus	Axillary	Lumbar	Not observed	Axillary
Habitat	Ponds, paddy field	Ditches, marshes	Streams, cascades	Streams, cascades

If we try to allocate *Micrixalus borealis* using these characters, it does not share tongue shape, extension of web, presence of pearl-tipped tubercles nor colour pattern of posterior shank with *Occidozyga lima*. It does not share longer finger I, presence of metatarsal web and glandular warts on skin with *Phrynoglossus martensii*. *Micrixalus borealis* has a notched tongue, a finger I much shorter than finger II, its shank shows not longitudinal pattern, its

metatarsal web is absent and its skin shows fine net-like skin ridges. It shares the absence of metatarsal web and the presence of these particular skin ridges with *Ingerana tenasserimensis*.

Considering behavioral characters, *Micrixalus borealis* specimens were collected in lotic habitat as were specimens of *Ingerana tenasserimensis*. *Occidozyga lima* is often found calling in ponds and paddy fields in open habitat. *Phrynoglossus martensii* is present in ditches and marshes in open habitat or secondary forests. *Phrynoglossus martensii* was described from Bangkok, its tadpole was first described from this town and it still can be found there everywhere. The ecological niche of *Micrixalus borealis* clearly is distinct from that of *Phrynoglossus* and *Occidozyga*, but corresponds to the niche of *Ingerana*. This supports change of generic allocation.

On behalf of these morphological and behavioral characters, *Micrixalus borealis* should be allocated to the genus *Ingerana* as *Ingerana borealis*. It is distinct from the two species presently allocated to this genus by its smaller size, absence of grooves on tip of fingers and toes and larger webbing.

SPECIFIC ALLOCATION

Comparison of the newly collected specimens with the onomatophore of *Micrixalus borealis* (ZSI 16932; see below) confirms specific allocation. The specimens from Mizoram correspond in general shape and size. They share the presence of a tooth like projection on lower jaw, rounded finger tips, relatively small webbing. Some character states differ. In the onomatophore, the tympanum is indistinct and no measurements have been taken, whereas in the specimens from Mizoram it is not very distinct but measurements could be taken. Differences in toe tip shape and presence of short groove may be consequences of poor conservation conditions of the onomatophore. Nevertheless some of the differences might indicate intraspecific variation over the range of *Ingerana borealis*. More comparative studies are needed to test this hypothesis.

DIAGNOSIS

Ingerana borealis is characterized by a combination of the following characters. Body and head: small-sized frog; head small and triangular; snout bluntly rounded, projecting in profile; canthus rostralis obtuse; loreal region concave; width of upper eyelid less than interorbital distance; tympanum rounded; supratympanic fold present; vomerine teeth absent; apical projection at the lower jaw prominent, pointed; a white spot between eye and upper jaw; a dark bar between eyes. Legs: fingers free; toes half webbed; metatarsal web absent; larger subarticular tubercles on toes than on fingers; outer metatarsal tubercle absent; inner metatarsal tubercle elongated, followed by tarsal fold; tips of digits dilated, rounded, grooves absent. Skin and colour: dorsum and flanks with net-like ridges and with tiny glandular warts; venter smooth, whitish yellow; dorsal colour grey or brown (in 8 % formalin) with light dorsolateral band. Sex characters: calling male with a pair of indistinct gular pouches on throat; females with 58-72 unpigmented eggs.

Table 2. – Measurements and some natural history parameters of *Ingerana borealis* from Mizoram, India.

Collection number	MZU-ZOO A.31	MZU-ZOO A.33	MZU-ZOO A.34	MZU-ZOO A.36	MZU-ZOO A.38	MZU-ZOO A.43	MZU-ZOO A.46	MZU-ZOO A.108	MZU-ZOO A.115	MZU-ZOO A.118	MZU-ZOO A.122
Sex	Female	Male	Female	Male	Female	Male	Female	Female	Female	Female	Male
Locality	Tuitun	Tuitun	Tuitun	Tandil National Wetland	Tandil National Wetland	Durlui	Durlui	MZU Campus	MZU Campus	MZU Campus	Zaniawntlang RF
SVL	24.50	21.9	23.14	21.82	24.7	19.96	24.35	25.54	28.12	28.08	23.95
SL	3.40	3.00	3.30	3.02	3.4	3.00	3.32	3.84	3.61	3.85	2.1
EN	2.82	1.45	1.62	1.37	1.60	1.58	1.64	1.90	1.68	1.47	1.72
NS	1.75	1.62	1.60	1.42	1.58	1.32	1.74	2.00	1.80	1.53	1.54
TE	0.86	0.67	0.94	0.90	0.74	0.82	1.03	1.02	1.18	1.23	0.98
IN	2.32	2.47	2.67	2.56	2.68	2.02	2.32	2.75	2.98	3.16	2.20
IOD	5.67	5.22	5.30	5.27	5.2	2.14	2.66	2.72	2.82	2.07	2.07
UEW	1.73	2.00	2.10	1.95	2.14	1.64	1.75	2.38	2.32	2.06	2.16
ED	2.8	2.9	3.33	3.33	3.06	2.96	3.38	3.62	3.36	3.38	3.23
HTYD	1.84	1.62	2.16	1.62	2.10	1.90	2.10	2.44	2.30	2.18	1.82
HL	7.24	5.96	6.00	6.50	6.50	5.68	7.75	7.74	8.40	7.75	6.85
HW	7.69	7.82	7.96	7.98	8.42	6.96	8.52	8.64	9.00	9.35	8.40
HDN	3.29	2.74	2.82	2.60	2.94	2.50	2.70	2.48	2.88	2.90	2.53
MN	5.52	4.36	5.07	5.32	5.27	4.42	5.16	5.31	5.40	5.33	5.10
MFE	3.96	3.55	3.73	4.14	4.40	3.32	3.88	4.15	4.05	4.95	4.10
MBE	1.82	2.24	2.60	2.65	2.55	1.76	1.85	2.20	2.48	2.68	1.50
IFE	4.04	3.58	4.03	3.95	3.94	3.26	3.80	4.60	4.90	4.48	3.90
IBE	5.61	5.58	5.96	5.60	5.98	5.00	5.86	6.64	6.92	6.66	5.65
FLL	13.74	11.7	12.9	12.42	13.70	11.44	14.10	15.06	15.14	14.82	13.15
F1	4.30	3.12	4.08	3.34	4.26	3.48	4.42	4.60	4.92	5.27	3.80
F3	4.92	4.04	4.80	3.94	4.83	3.90	5.02	5.15	5.57	5.62	4.12
F3	6.32	6.20	6.52	5.46	6.50	5.12	6.36	6.56	6.72	6.85	5.70
F4	5.84	4.58	5.10	4.30	5.62	4.12	5.23	5.46	6.14	5.94	4.86
F,D	0.68	0.52	0.73	0.65	0.69	0.58	0.76	0.73	0.83	0.76	0.54
F,D	0.77	0.54	0.86	0.80	0.91	0.68	0.92	0.66	0.90	0.87	0.58
HLL	36.63	33.40	36.18	34.06	35.10	30.96	40.87	41.20	44.28	41.93	35.44
TL	12.26	11.58	12.76	11.47	13.00	10.44	13.44	13.15	14.07	14.12	11.94
TW	3.72	3.52	3.67	3.90	4.60	3.02	3.68	4.68	4.55	4.45	3.10
T1	4.34	4.30	5.07	5.25	5.53	3.78	4.88	5.56	5.40	5.68	4.77
T2	6.24	5.86	6.55	6.98	7.56	5.72	7.35	7.83	7.20	7.46	6.60
T3	8.43	8.40	9.28	8.78	9.86	8.30	9.78	10.72	10.48	10.94	9.22
T4	10.94	10.72	11.84	11.32	12.60	9.45	12.66	13.26	13.21	14.10	11.34
T5	8.38	7.84	9.10	8.50	9.57	7.14	8.64	10.38	10.23	10.58	8.70
T,D	0.78	0.78	1.08	0.86	1.02	0.52	0.98	0.76	1.00	1.00	0.75
T,D	0.76	0.84	1.00	1.00	1.07	0.74	1.02	0.82	1.06	1.14	0.79
TMT	1.42	1.2	1.36	1.80	1.38	1.08	1.88	1.18	1.92	1.93	1.48
Tibio-tarsal articulation	Anterior corner of eye	Posterior corner of eye	Middle of eye	Middle of eye	Anterior corner of eye	Middle of eye	Between eyes and nostril	Between eyes and nostril	Anterior corner of eye	Anterior corner of eye	Anterior corner of eye
Gut content	Hymenoptera, isopteran nymph	Adult winged Isoptera, Diptera	–	Isopteran nymphs (2)	Diptera (2), Hymenoptera	Diptera	Isopteran wings	Isopteran worker, winged Isoptera (2)	Adult wingless Isoptera (2), isopteran nymph, small Myrmecidae	–	–
No. of eggs	68	–	65	–	72	–	–	58	62	67	–
Size of eggs	1.43-2.20 mm	–	1.34-2.24 mm	–	1.26-2.28 mm	–	1.24-2.13 mm	1.20-2.62 mm	1.38-2.78 mm	1.23-2.88 mm	–

DESCRIPTION OF HOLOPHORONT OF *MICRIXALUS BOREALIS* ANNANDALE, 1912

ZSI 16932, sex not studied. Rotung (1300 ft = 400 m), South of Yembung, Arunachal Pradesh, India.

(A) *Size and general aspect.* – (1) Specimen of small size (SVL 20.4 mm), body stout.

(B) *Head.* – (2) Head moderate, wider (HW 8.4 mm) than long (HL 7.4 mm; MN 6.6 mm; MFE 5.6 mm; MBE 3.0 mm), convex. (3) Snout rounded, not protruding; its length (SL 3.18 mm) longer than horizontal diameter of eye (EL 2.87 mm). (4) Canthus rostralis indistinct, loreal region concave, obtuse in cross section. (5) Interorbital space flat, less broad (IUE 1.83 mm) than upper eyelid (UEW 1.67 mm) but narrower than internarial distance (IN 2.49 mm); distance between front of eyes (IFE 3.8 mm) about three fourth of distance between back of eyes (IBE 6.2 mm). (6) Nostrils rounded, without flap of skin laterally, closer to eye (EN 1.17 mm) than to tip of snout (NS 1.86 mm). (7) Pupil oval, horizontal. (8) Tympanum indistinct. (9) Pineal ocellus absent. (10) Vomerine ridge and teeth absent. (11) Tongue moderate, rounded, emarginate; median lingual process absent. A prominent unique tooth-like projection medially on maxilla. (12) Supratympanic fold poorly distinct, from eye to level of lips.

(C) *Forelimbs.* – (13) Arm short, fore-arm (FLL 4.5 mm) shorter than hand (HAL 5.6 mm), not enlarged. (14) Fingers short, thin (F₃ 2.47 mm). (15) Relative length of fingers, shortest to longest: F₁ < F₂ < F₄ < F₃. (16) Tips of fingers I to IV rounded, not enlarged. (17) Finger II with dermal fringe; webbing absent. (18) Subarticular tubercles indistinct, rounded, single, tubercles of finger IV absent. (19) Prepollex indistinct; palmar tubercles indistinct; supernumerary tubercles absent.

(D) *Hindlimbs.* – (20) Shanks three times longer (TL 11.8 mm) than wide (TW 3.6 mm), longer than thigh (FL 10.8 mm) and distance from base of internal metatarsal tubercle to tip of toe IV (FOL 10.9 mm). (21) Toes long, thin, toe IV (T₄ 7.40 mm) longer than third of distance from base of tarsus to tip of toe IV (TFOL 15.7 mm). (22) Relative length of toes, shortest to longest: T₁ < T₂ < T₅ < T₃ < T₄. (23) Tips of toes rounded, slightly enlarged. (24) Webbing moderate: I 0 – II 0 – 2 III 2 – 2 IV 3 – 1 V (MTTF 6.84 mm; MTFF 6.36 mm; FTFT 3.66 mm; FFTF 4.77 mm). (25) Dermal ridge along toe V absent. (26) Subarticular tubercles indistinct, oval, simple, all present. (27) Inner metatarsal tubercle indistinct, short, its length (IMT 1.36 mm) 1.83 times in length of toe I (T₁ 2.49 mm). (28) Tarsal fold absent. (29) Outer metatarsal tubercle, supernumerary tubercles and tarsal tubercle absent.

(E) *Skin.* – (30) Dorsal and lateral parts of head and body: snout smooth; between eyes, side of head, back and flank roughly shagreened. (31) Cephalic ridges absent. (32) Dorsolateral folds absent; "Fejervaryan" line absent; lateral line system absent. (33) Dorsal parts of limbs: forelimb shagreened; thigh and leg roughly shagreened; tarsus smooth. (34) Ventral parts of head, body and limbs: throat with indistinct glandular warts; chest and upper belly smooth; posterior part of belly smooth. (35) Macroglans absent.

(F) *Coloration in alcohol.* – (36) Dorsal and lateral parts of head and body: dorsal parts of head and body brown with a dark band between eyes and a dark chevron between shoulders;

flank brown with darker spots; loreal region and upper lip brown with ivory white spots; tympanic region brown. (37) Dorsal parts of limbs: brown with indistinct darker brown bands; posterior part of thigh brown. (38) Ventral parts of head, body and limbs: throat and its margin dirty white covered with brown shade; chest ivory-white with brown spots on sides, belly dirty white; thigh dirty white with brown spots on border; webbing dirty white with few brown spots.

(G) *Sexual characters*. – Not observed.

DESCRIPTION OF SPECIMENS FROM MIZORAM

Size. – A small-sized frog (fig. 1), mature males SVL 19.96-23.95 mm ($n = 4$); gravid females SVL 23.14-28.12 mm ($n = 7$).

Head. – Head shorter than broad, small triangular. Snout blunt in shape, convex at tip projecting beyond mouth; canthus rostralis obtuse; loreal region concave; width at angle of jaws around $2\frac{1}{2}$ times distance from tip of snout to anterior corner of eye. Nostril equidistant from tip of snout and eye; length of snout slightly longer than diameter of eye; internarial distance larger than interorbital distance; tympanum round, not distinct and nearly half of eye diameter; supratympanic fold starting from posterior corner of eye and ending at level of forelimb insertion. Upper jaw bearing teeth; vomerine ridge absent; choanae situated far forward, partially covered by musculature. A tooth-like structure at apex of lower jaw, prominent and pointed; tongue small, free and bifid.

Forelimb. – Moderately strong, more than half of snout-vent length; fingers thin, small, without webbing between them; first finger slightly shorter than second; no inner metacarpal tubercle on hand. Fingers dilated into rounded discs; discs longer than broad; subarticular tubercles of hand distinct and prominent, smaller than subarticular tubercles of feet. Relative length of fingers, shortest to longest: $F_1 < F_2 < F_4 < F_3$.

Hindlimb. – Hindlimbs stout; exceeding total body length; tibiotarsal articulation reaching eyes. Heels slightly overlapping when hindlimbs folded at right angle to body. Tibia short, half of snout-vent length; its width about $\frac{1}{3}$ of its length. Toes slender; an elongated inner metatarsal tubercle present at base of first toe, followed by tarsal fold; outer metatarsal tubercle absent. Relative length of toes, shortest to longest: $T_1 < T_2 < T_5 < T_3 < T_4$. Discs of toes small, bearing a narrow median groove. Subarticular tubercles moderately prominent. Webbing small, not quite reaching discs of first and fifth toes. Webbing moderate: I 1-1 $\frac{1}{2}$ II 1-1 $\frac{3}{4}$ III 1-2 $\frac{1}{2}$ IV 3-1 V.

Skin. – Dorsum as well as flank region rough with numerous tiny glandular warts forming net-like ridges; skin of snout, between eyes, upper eyelids and lateral side of head above the supratympanic fold uniformly granular, below fold smooth; throat and chest smooth to shagreened; belly and inner part of limbs smooth but outer limbs with minute warts; glandular warts on the outer shank larger than those of outer thigh; skin around anus shagreened to granular; anus unmodified, directed posteriorly, at upper level of thighs.



Fig 1. *Ingerana borealis* (MZU-ZOO A.46), SVL 24.35 mm, female, at Durlu (Mizoram; 23°53' 508"N, 92°29' 056"E, 110 m asl)

Colour – Dorsal colour varying from light grey to light brown spotted with dark grey to dark brown; pupil rounded and bluish-black; flanks darker, throat and chin tinted with light grey; belly white or slightly light yellow without any markings, inner limbs including hands and feet light yellow, limbs and digits speckled with faint dark bands. A faint black line running from throat region to level of groin ventro-medially. A dark brown canthal stripe from snout to eye; one prominent white spot present between eye and upper jaw. A dark bar present at posterior region of interorbital space, snout darker. A prominent light yellow dorsolateral stripe extending from posterior corner of eye to level above insertion of hindlimb, demarcating lighter grey or light brown dorsum from darker flanks. Webbing whitish yellow.

Sexual dimorphism. – (a) Males, comparatively smaller in size; a pair of indistinct gular pouches present on throat of calling male. (b) Female, comparatively larger in size, wider abdomen during breeding season

Distribution – ANNANDALE (1912) collected the type specimens of *Micrixalus borealis* from close to Mouling National Park (Arunachal Pradesh) and after nine decades PAWAR & BIRANI (2001) rediscovered the species in Pakhui Wildlife Sanctuary and Nameri National Park. MATTHIJS & SEN (2003) reported it from Baghmara Reserve Forest, South Garo Hills and Narpuh Reserve Forest, Jainta Hills (Meghalaya) AO et al (2003) recorded it from

Medziphema (Nagaland) and ASMAT *et al.* (2003) from Rangamati Hill district in Bangladesh. The present study recorded this species from the two districts of Mizoram, i.e., Aizawl district and Kolasib district. In Aizawl district they were collected in Lawibual stream (23°43'193"N, 92°44.328'E; 743 m asl), Mizoram University Campus (23°43.081"N, 92°43'668'E; 915 m asl), Tamdil National Wetland (23°44.399"N, 92° 57'313"E; 745 m asl), Durlui (23°53'508"N, 92°29.056'E; 110 m asl). In Kolasib district they were found in Tuitun stream (23°58.213'-58.402"N, 92°41.055'-41.104'E; 300-325 m asl) and Zanlawntlang Reserved Forest (23°56.116"N, 92°43'465'E; 748 m asl). The present records add not only new data to the distributional information of the species in north-eastern India, but also to the altitudinal distribution. It is notable that many of these specimens, except those collected in Durlui and Tuitun stream, came from elevations above 740 m asl and up to 915 m asl; our Bhutan specimens were collected at 1000 m asl, thus extending the elevational range much above the 400 m asl given in the literature (STUART *et al.*, 2008). This species is not rare in the two districts of Mizoram where it could be easily observed during our study. Further exploration will probably reveal that *I. borealis* is present in other parts of this region, and its range may be throughout the state.

Natural history. – *Ingerana borealis* is a widely distributed species in our current study sites, found in and around lotic water sources mostly in canopy area, marshes and wetlands. During our survey, most of the specimens were found at night among litter and boulder in trickling and cascading streams in and around forests. Most of them were seen perching on the wet rocks within the stream or on the streamside rock ledges, about 1-5 m away from the water surface. In Mizoram, this frog can be observed from the onset of monsoon onwards. During day time, the frogs remained inside the crevices of rock as well as under moist leaf litter and bushes. Other amphibian species found in sympatry include *Amolops marmoratus* (Blyth, 1855), *Fejervarya limnocharis* group, *Polypedates leucomystax* group, *Nasuana alticola* (Boulenger, 1882), *Sylvirana cf. nicobarensis* (Stoliczka, 1870), *Kaloula pulchra* Gray, 1831, *Microhyla berdmorei* (Blyth, 1856), *Leptobrachium smithi* Matsui, Nabhitabhata & Panha, 1999 and *Xenophrys parva* (Boulenger, 1893).

During the present study, *Ingerana borealis* was found from April to August, which indicates that the species is a seasonal breeder. We observed that breeding in this species is related to rainfall with the breeding peak taking place from May to July. The male calls from outside water and amplexus is axillary. Frogs in amplexus are seen from around 22.30 h on the margin of water, near the bank. No eggs and larvae of this species have been recorded. Remarkably, in laboratory, maintained amplexing pairs did not lay eggs.

CHANDA (2002) reported that no data were available on the wild status of the species and may warrant inclusion in the Indian Wildlife (Protection) Act, 1972. The new data published here may fill this gap. As indicated from range extension and abundance in the field, this species might be changed to LC (Least Concern) in IUCN categories.

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